CARE IN CAPTIVITY

Monitor Lizard Husbandry

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Introduction

Monitor lizards have become increasingly popular with reptile hobbyists over the past few years. This recent surge in interest can be attributed, in part, to the increased availability of species that were historically inaccessible to most herpetoculturists. These include, the black rough-necked monitor, *Varanus rudicollis*, from Southeast Asia and the crocodile monitor, *V. salvadorii*, from New Guinea. Currently, the savannah monitor, *V. exanthematicus*, the Nile monitor, *V. niloticus*, and the water monitor, *V. salvator*, are the more abundant species in collections in the United States, due to their relative availability in the pet trade. According to Slavens[1] there were about 50 savannah monitors and 35 each of Nile and water monitors, maintained in institutions reported in his inventory in 1992. For the other species the number was generally less than 15 specimens and in most cases much less. Clearly, this does not account for the many specimens held in private collections. There also has been an increase in popular literature in regards to this group. Although, the quality of this literature varies widely, it still has stimulated increased popularity in this group of lizards.

This article will discuss methods believed to contribute to successful captive management and in some cases reproduction of monitors. These lizards have adapted to a wide variety of habitats, from deserts to rain forest, and so, specific recommendations on groups of species with similar natural histories are given. Because of the scarcity of natural history information available for this group, some broad generalizations will be made. Important works of interest in the areas of husbandry, natural history and taxonomy are included in appendices I, II and III.

Brief Taxonomic Overview

There are currently about 42 recognized species of monitor lizards living today and all are placed in the genus Varanus. Members of this family (Varanidae) are distributed throughout Africa, Southern Asia, the Philippines, Indonesian Archipelagos and Indo-Australia, with the majority of species, about 25, occurring in Australia.[2] The largest living species is the Komodo dragon, *V. komodoensis*, from the Lesser Sunda Islands in the Indonesian Archipelago. This species is capable of reaching a length of up to ten feet and weigh around 114 kilograms (250 pounds). An extinct species from the Pleistocene of Australia, *Megalania priscus*, may have been at least twice that length and weighed around 4500 pounds.[3] The smallest living species is the short-tailed monitor, *V. brevicauda*, from western Australia, seldom growing longer than eight inches. Varanidae currently lacks a consistent hypothesis of systematic relationships thus no attempt will be made to summarize the systematic allocations.

Adaptations to Habitat

A few wide-ranging species, such as the Asian water monitor, and Gould's monitor, *V. gouldii*, are found in a variety of habitats throughout their range.[4,5] However, in most cases, habitat types for monitors fall into one of several broad categories for which they have developed specialized adaptations. One such specialized species is the black tree monitor, *V. beccari*, from Aru Island off the coast of New Guinea. This species grows to a length of about 12 inches from snout to vent with a prehensile tail nearly twice the length of the body. The long prehensile tail and sharp re-curved claws make it ideally suited for its arboreal habits.

In contrast, other species have evolved to exploit riparian habitats. These monitors often shelter and bask in the vegetation around bodies of water. These include the mangrove monitor, *V. indicus*, from the Indo-Papuan Archipelago and the Cape York Peninsula of Australia and Merten's water monitor, *V. mertensi*, from northern Australia. These semi-aquatic animals have flattened tails and nostrils positioned high on the snout for swimming.

The other two major habitats exploited by varanids center on rocky outcrops and terrestrial habitats. All of the African and

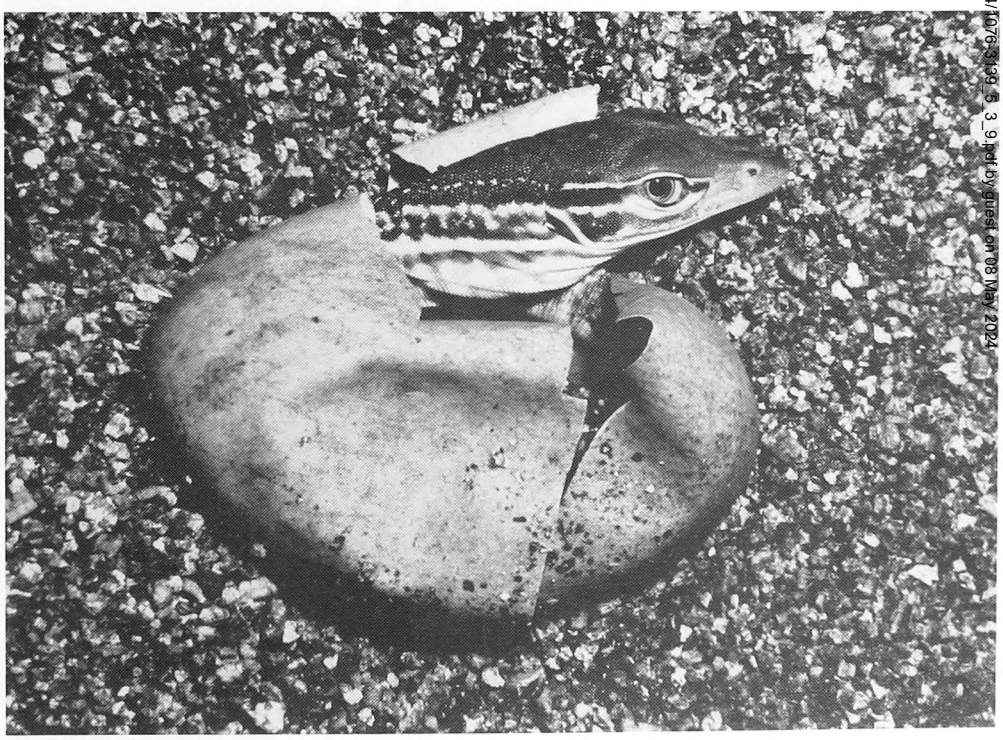

Figure 1. Gould's monitor, *Varanus gouldii* , in the process of hatching. *Photo by DM Boyer.*

many of the Australian species are associated with one of these two habitats. Many of these species, such as Gould's monitor, have strong stocky front limbs for excavating burrows and digging out prey items.

Behavior

Some members of this family forage widely. One study found that Gould's monitors often cover nearly two square kilometers a day in search of food.[6] One species, the Komodo dragon, is more of an ambush predator, sitting near game trails waiting for potential prey to come into range before charging out to capture it with its powerful jaws. Even if prey manages to escape from this species, it is not likely to survive long. Komodo dragons carry infectious bacteria in their mouth which usually does them no harm, but often causes major systemic infection and death in bitten animals.

Monitor lizards tongue-flick frequently while active. Their tongue morphology is very snake-like and is presumably important in acquiring chemical information from prey, conspecifics and possibly predators. One study demonstrated that ingestively naive neonate Gould's monitors are able to discriminate between chemical cues from prey and non-prey items at birth.[7]

In most cases monitors appear to maintain large home ranges and are generally not found in social groups outside the breeding season or coincidental feeding aggregations at large carrion deposits. Males in particular tend to be intolerant of one another, especially in the presence of cycling females. At times, females can also become aggressive towards conspecifics.[8] This suggests that specimens are best maintained individually outside of the captive reproductive season.

General Management

Before an appropriate captive environment can be designed for any species, some effort must be made to research its natural history. The captive environment must reflect those aspects of an animal's natural history that are considered vital to its existence. For example, medium sized arboreal species, such as the black tree monitor, and the green tree monitor, *V. prasinus*, will require adequate vertical space for climbing. One way to accomplish this is by modifying a 30 gallon PVC sink by fitting the top lip of the sink with a wood or plexiglass structure about three feet high. This can then be fitted with a door and a screen top for ventilation. These species will usually refuse to drink from standing pools of water and will require a "rain system" of some sort to prevent dehydration.

Providing large arboreal species, such as the crocodile monitor and the black rough-necked monitor, with adequate space can be a challenge, especially if specimens are not housed outdoors for all or part of the year. Single specimens can be temporarily maintained in corrugated metal troughs with secure lids. Housing these animals indoors permanently requires much more space than all but the most dedicated monitor enthusiast is willing to devote to a single animal. Some of the largest species, such as the crocodile monitor, require dedicated rooms, at least during the captive reproductive season.

Active terrestrial species, such as Gould's monitor, require fairly spacious vivariums to accommodate their active nature. While not particularly active, savannah monitors also require a fair amount of space if these animals are expected to thrive and reproduce. The corrugated metal troughs described above work well for these species; although single individuals have been maintained for long periods in much smaller enclosures. Bath tubs can also be fitted with secure lids and utilized for enclosures.

For riparian species, such as the mangrove monitor, the above described enclosures can be fitted with a drain and slightly elevated at one end to create a pool. There are many variations of enclosure designs that are successful. It is important that one provide for the habits of the given species.

Monitors are fairly messy creatures generating a large amount of fecal material. Enclosures should be designed so that cleaning can be accomplished easily. Generally this is accomplished without substrates or with substrates that can be discarded, such as newspaper. Some of the small terrestrial monitor species do well on

Figure 2. An adult Storr's monitor, *Varanus storri*, from Western Australia. *Photo by DM Boyer.*

course sand/gravel substrates. Monitors kept on too smooth a substrate may develop overgrown claws, too rough a substrate may result in extremely worn claws with possible damage to palmar surfaces or formation of large calluses.

Monitors should have access to water and many prefer to defecate in their water bowl. Accordingly, water bowls should be large enough for the monitor to soak in and easy to remove for cleaning. Appropriate sized bowls and glass or plastic pans are suitable for smaller specimens. For medium to larger specimens plastic sink pans, tubs with handles (such as the Rubbermaid® Scrubbin Tub), concrete mixing tubs or built-in plumbed pools are practical. Water should be changed whenever dirty, usually daily to every other day.

An assortment of hollow logs, corkbark slabs, branches and rocks can be utilized as cage furniture. Live plants and delicate props fair poorly with most monitor species. Some shy species, especially the forest monitors, may require extra cover at first. Once specimens begin to acclimate, some cage furniture can be removed to facilitate cleaning. Remember, the more difficult an enclosure is to clean, the less likely it is to be cleaned thoroughly.

It will be necessary to provide specimens housed indoors for all or part of the year with a source of unfiltered ultraviolet (UV) light of the proper wavelength. While it is true there is no conclusive evidence documenting the benefits of UV light in reptiles, there is sufficient anecdotal evidence to demonstrate its importance in at least the proper development of neonatal monitors.[10] In addition, remember to provide a basking area for indoor specimens. This is best accomplished with an incandescent spot light. A temperature gradient between 26°C to 35°C (80°F - 95°F) is optimal. Avoid the use of hot rocks as these products tend to cause low-level burns over time. This may be because heliothermic reptiles, including most if not all varanids, may not be receiving appropriate cues that are received when basking under a light source.

Figure 3. An example of a rough-necked monitor, *Varanus rudicollis.* This Asian forest monitor has recently become a common species in the pet trade. *Photo by DM Boyer.*

Feeding

There is some disagreement over what constitutes a proper captive diet for varanids. Once again, this can be attributed to the lack of natural history information for most species. In cases where we do have dietary information for wild specimens, it appears that the natural diet for most species consists primarily of a wide variety of invertebrates, carrion and in one species, fruits and seed.[4,9,10,11]

Gray's monitor, *V. olivaceus*, an arboreal species from the Philippines, is the lone species known to include fruit as a regular part of its diet.[9] This species' specialized diet has made captive management problematic as native fruits are unavailable outside the Philippines. Some individuals have, on occasion, accepted some cultivated fruits (grapes) on an irregular basis. One solution to this problem is to inject fruit baby food into pre-killed mice, which this species readily accepts in captivity.[9] Unfortuneately this monitor continues to fair poorly in captivity and part of its problem may well be diet related.

For most other species a varied captive diet of whole fish, rodents, rabbits, chickens, insects (crickets, wax moth larva, mealworms, grasshoppers, locust, moths) and other invertebrates (snails and crustaceans) is recommended. Small amounts of beef or chicken parts can be offered but are severely calcium deficient without bone and can transmit *Salmonella* and *Arizona*. Commercial large carnivore diets can also be offered from time to time. Canine or feline diets are convenient but could be a health hazard over time and are best minimized or avoided altogether.

Food items, such as crickets and small mice, should be broadcast into enclosures to elicit foraging behavior. It is hypothesized that feeding smaller prey items and exercise while foraging helps prevent stagnation in long term captives.[12] When offering live rodents, only small live mice are recommended, as larger rodents can cause serious injury. Live rodents that are not consumed by the end of the day should be removed to prevent possible injury to the monitors. Larger rodents should be killed or stunned before offering. Partially opening the coelom of larger killed prey items may aid digestion.

Young rapidly growing monitors are particularly prone to metabolic bone disease. This can be avoided by providing whole rodents or fish, UV light and ensuring that potential food items are fed a proper well balanced diet. The later particularly applies to calcium deficient insects, which should be fed fortified cricket diets for two to three days prior to being consumed or dusted with calcium carbonate, lactate or gluconate. Additional multivitamin or mineral supplementation is not needed for other well fed whole animal prey.

Juveniles should be fed two to three times a week and adults once or twice a week or less. Obviously large monitors need to feed less frequently than active insectivorous species. Females need extra food for egg yolk development. Obesity, particularly in males, can be a problem with the sedentary captive lifestyle. Periodic physical examinations and weight checks are important to determine excess weight gain or loss but keep in mind that seasonal variation is normal for some species (discussed later).

Sexing

Sexual dimorphism is not apparent in varanids and methods currently utilized for sexing these animals, such as probing, are inconclusive. A technique involving the insertion of a fiberoptic scope into the cloaca of anesthetized specimens in an attempt to verify the presence or absence of hemipenes was thought to be successful in Dumeril's monitor, *V. dumerili*.[13] However, sex determination was found to be inaccurate when the specimens were later necropsied.[14] The method of injecting sterile saline into the base of the tail to evert a hemipene can be potentially harmful and is not entirely reliable. In some species, sex can be determined in adult specimens by radiographing the base of the tail. Two, or in some species three, mineralized structures in the retracted hemipenis of males should appear on the radiographs. However, these mineralized structures cannot be seen in *V. bengalensis*, *V. dumerili*, *V. exanthematicus*, *V. griseus*, *V. mertensi*, *V. niloticus*, *V. rudicollis*, *V. salvator* or *V. timorensis*.[16] Young male juveniles will often evert one or both hemipenes when slight pressure is applied to the base of the tail or with defecation. Physically everting hemipenes becomes more difficult as the animal matures and gains strength but can sometimes still be accomplished under general anaesthesia. Males often evert on or both hemipenes when defecating. However, females sometimes evert large cloacal glands while defecating, and these are sometimes mistaken for hemipenes.

Laparascopic visualization of the gonads is sometimes used as a method of sex determination and may be useful in those species without mineralized hemibaculum.[16] Inexperienced veterinarians attempting to apply this technique have occasionally misinterpreted fatty deposits for ovaries. Although this is a minimally invasive procedure, it does require anaesthesia and probably should be delayed until the animals are well established.

Figure 4. The Crocodile monitor, *Varanus salvadorri*, is the longest species of varanid obtaining lengths of up to 12 feet. *Photo by DM Boyer.*

Breeding

Specimens should be maintained individually and introduced for short periods during the captive reproductive season. This does not necessarily coincide with the natural reproductive season and will be determined through the manipulation of the appropriate seasonal cues. In one field study, white-throated savanna monitors, *V. albigularis*, were found to have dramatic seasonal differences in body mass in both males and females.[17] Body mass during the wet season exceeded dry season body mass by 50 percent. This may be an important seasonal cue for this species. See Card,[18] 1995, for a more detailed discussion of the importance of manipulating seasonal cues in the captive environment. Introductions should coincide with lengthening photoperiods and rain cycles in those species that require rain systems. Specimens can be introduced bi-weekly for several days until courtship or copulation is observed. Pairs should then be left together until breeding activity ceases.

Gravid females should be provided with nest chambers of some sort. Twenty-five gallon plastic trash cans, filled with soil or sphagnum moss, work well for some of the medium to large species, such as Gould's monitors, Gray's monitor, and water monitors. Smaller Rubbermaid® or plastic tubs can be used for smaller species.

Egg Incubation

Eggs can be incubated either in sealed one-gallon glass jars or ten-gallon aquaria with vermiculite and water in a 1:1 ratio by weight. Occasionally, containers should be opened for a few minutes to allow fresh

air to circulate around the eggs. Incubation times for eggs at 28°C (82°F) varies from 95-101 days for *V. gilleni* to 229-235 days for *V. gouldii*. Eggs have been successfully incubated at slightly higher temperatures, but this may reduce survival of young. Because of the lengthy incubation times for monitors, it is vital that temperature and relative humidity be carefully monitored. Moisture loss can be measured by initially weighing the container housing the eggs and adding water to replace any lost during the incubation process. Frequent handling of the eggs should be avoided during incubation as they appear to be fairly sensitive to movement.[19]

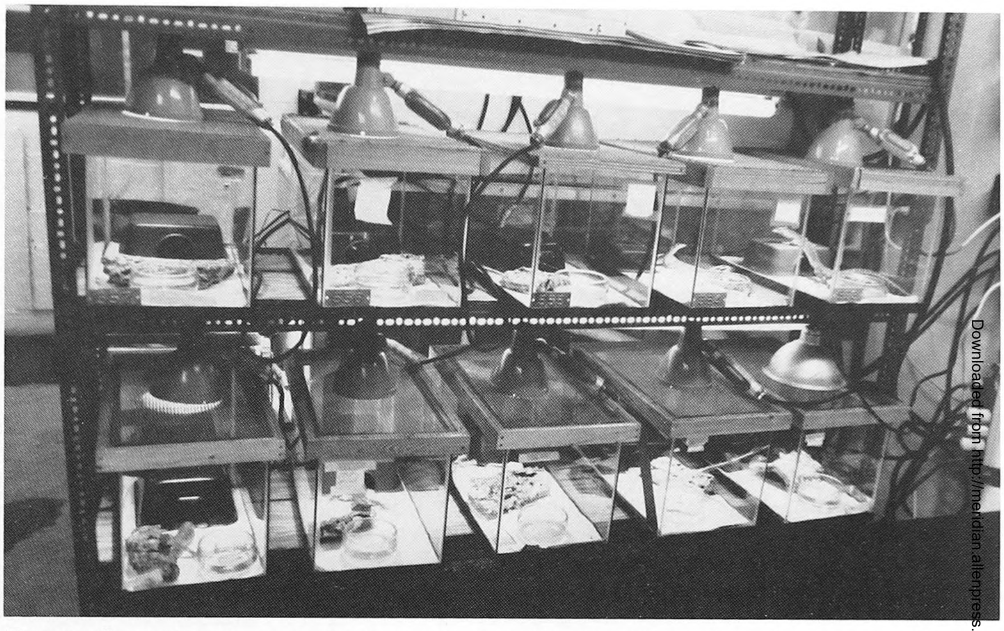

Figure 5. A simple set up for large numbers of neonatal monitors. These young Gould's monitors can be maintained in 10 gal aquaria for up to a year. *Photo by DM Boyer.*

Neonatal Care

Hatchlings of terrestrial species can be maintained in 10-gallon aquaria and provided with a hide box, water dish and artificial UV light source and a 50-watt incandescent spotlight. In addition, hatchlings of arboreal species should be provided with adequate vertical space for climbing and a drip system to prevent dehydration. Domestic crickets, waxworm larva, mealworms and pre-weanling mice are usually accepted by neonates a week or so post-hatchling (see the feeding section for more information). On occasion, food items must be crushed to expose internal fluids to elicit feeding.

Parasitic Considerations

Because of minimal reproductive success in captive monitors, most captives are wild-collected. This is unfortunate since wild-collected varanids fair poorly in captivity. A survey of the medical histories of Asian forest monitors (*V. beccari*, *V. dumerili*, *V. olivaceus*, *V. prasinus*, *V. rudicollis*, *V. salvadorii*) maintained in North American zoos, revealed mortality for recently imported specimens of roughly 35% in the first 90 days after zoo acquisition.[20] Necropsies revealed a large number of intestinal parasites. It should be noted that parasite validity is unconfirmed because it is not known who identified the parasites nor how accurate the identifications were. Treatment efficacy also remains unknown because follow-up fecal examinations were not reported. Drug dosages have not been included because of the wide range of recommendations in the literature.

Perhaps massive parasitic infestations, combined with stress, inappropriate husbandry and lack of medical guidelines, contribute to the high mortality of monitors. The extraordinarily high mortality rate in zoos is likely to be at least as high in the private sector.

Nematodes (*Physaloptera sp.*), and protozoans (*Cryptosporidium sp.*, *Entamoeba sp.*), were identified in the black tree monitor.[20] Treatment (except for *Cryptosporidium sp.*) involved ivermectin (Ivomec, Merck AgVet, Rahway, NJ) or metronidazole (Flagyl, G.D. Searle & Co., Chicago, IL) with no adverse reactions noted. However, in the rough-necked monitor, ivermectin has been reported to cause seizure-like activity, so caution should be taken when using this drug.[20]

Cestodes, protozoans and *Strongyloides sp.* were reported in Dumeril's monitor.[20] Clinical problems were not reported for cestodes, the significance of protozoans remains unknown. *Strongyloides* has a direct life cycle and therefore sanitation is the key to prevention. Specimens with *Strongyloids* were treated with fenbendazole (Panacur, Hoechst-Roussel, Somerville, NJ) with no adverse reactions.

Endoparasites identified in the green tree monitor, *V. prasinus*, included cestodes, nematodes (*Strongyloides sp.*, spirurids, strongylids or hookworms, and oxyuroides or pinworms) and protozoa (amoeba, ciliates, flagellates and coccidia).[20] The cestodes were treated with praziquantel (Droncit, Miles Inc., Shawnee, KS), nematodes with fenbendazole, ivermectin or levamisole HCL (Levasole injectable solution, 136.5 mg/ml, Mallinckrodt, Mundelein, IL), ciliates and amoeba with metronidazole. Strongyles can potentially induce anemia or enteritis. Their life cycle is direct so thorough cage cleaning would help in the prevention of infestation. Oxyurids have simple and direct life cycles and are believed to cause little problem for the host monitors. Pinworm ova from prey may also be present in monitor feces and should not be misinterpreted as ova from monitor parasites. One facility found a pentastomid-related pneumonia at necropsy. As pentastomids are zoonotic, care should be exercised in handling carrier monitors. There is no proven treatment except for surgical or endoscopic removal of the parasites.

In the crocodile monitor and the black rough-necked monitor many of the same intestinal cestodes, nematodes, and proto-

zoans were found in addition to *Capillaria sp.* and other ascarids.

Handling

Finally, it should be noted that adults of many species can cause severe injuries to the handler if improperly restrained. Individuals with little or no experience handling large lizards should consider starting out with one of the less nervous species, such as the savannah monitor. It might also help to visit a local zoo, or contact a local herpetological society or knowledgeable owner to get instructions on proper handling techniques.

Varanids are visually oriented animals, therefore covering their eyes will reduce the chances of being bitten during the initial restraint procedure. A firm grip should be made just behind the head. The thumb and index finger of the free hand should be placed around the pelvic region with one hind limb placed between the middle and ring fingers. This grip will prevent animals from rolling out of the hands of the restrainer. The muscular tails of some species can be used as formidable defensive weapons and should be restrained by a second person. If a second person is unavailable, the tail can be held firmly under the arm pit. Ideally specimens should be held away from the restrainer's body to prevent being scratched by the animal's claws. Also, when larger animals are physically restrained, copious amounts of projectile fecal matter are usually expelled from the cloaca. Having a second person cover the vent with a free hand will sometimes help prevent or at least reduce this problem.

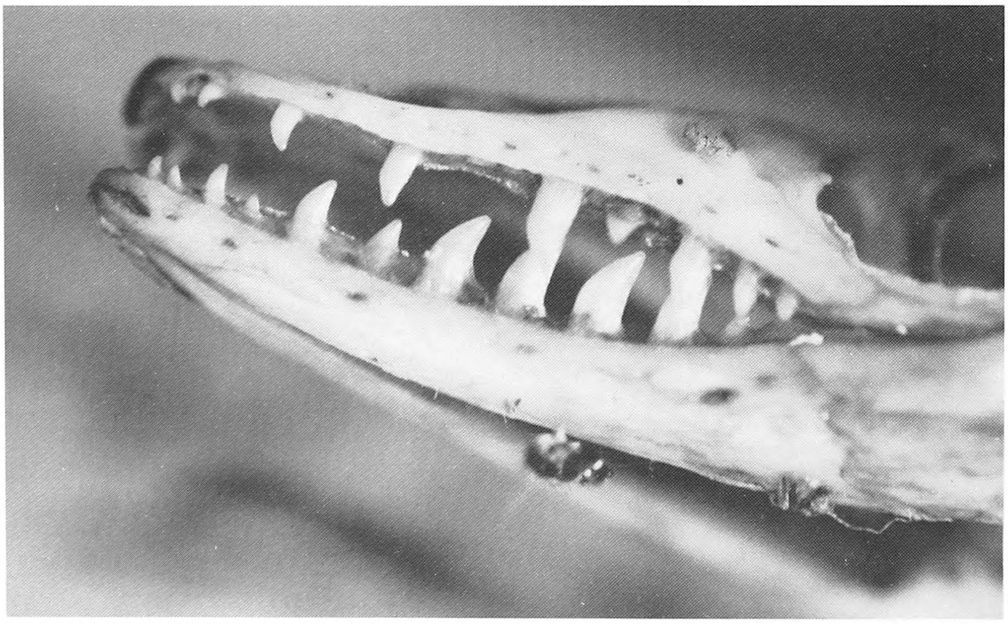

Figure 6. The long, recurved teeth shown here belonged to an adult black-tree monitor, *Varanus beccari*. Although this is a relatively small species its bite can be very painful. *Photo by DM Boyer.*

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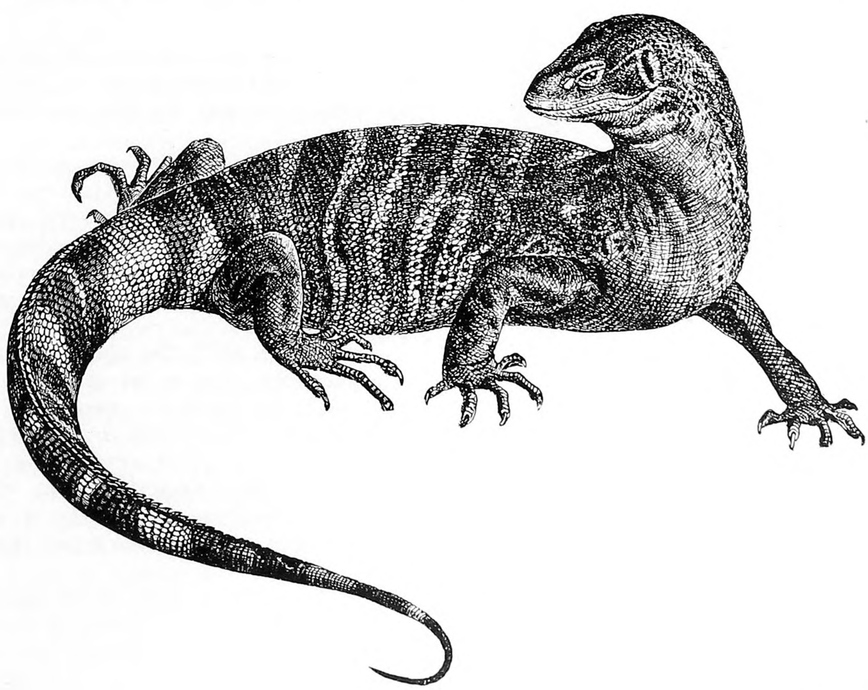

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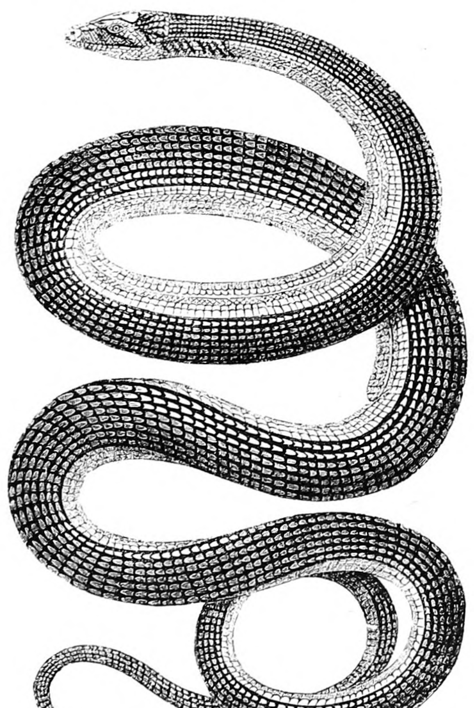

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